CLAIMS:

1. An ultrasonic waterjet apparatus comprising:

   a) a generator module having:

      i) an ultrasonic generator for generating and transmitting high-frequency electrical pulses;

      ii) a control unit for controlling the ultrasonic generator;

      iii) a high-pressure water inlet connected to a source of high-pressure water;

      iv) a high-pressure water outlet connected to the high-pressure water inlet;

   b) a high-pressure water hose connected to the high-pressure water outlet;

   c) a gun connected to the high-pressure water hose, the gun having an ultrasonic nozzle having a transducer for receiving the high-frequency electrical pulses from the ultrasonic generator, the transducer converting the electrical pulses into vibrations that pulsate a waterjet flowing through the nozzle, creating a waterjet of pulsed slugs of water, each slug of water capable of imparting a waterhammer pressure on a target surface.

2. An ultrasonic waterjet apparatus as claimed in claim 1 wherein the transducer is a piezomagnetic transducer made of a magnetostrictive material.

3. An ultrasonic waterjet apparatus as claimed in claim 2 wherein the magnetostrictive material is a Terfenol™ alloy.

4. An ultrasonic waterjet apparatus as claimed in claim 3 wherein the piezomagnetic transducer is a cylindrical core within a coil and a bias magnet.

5. An ultrasonic waterjet apparatus as claimed in claim 3 wherein the piezomagnetic transducer is a tubular core within a coil and a bias magnet.

6. An ultrasonic waterjet apparatus as claimed in claim 1 wherein the transducer is a piezoelectric transducer.

7. An ultrasonic waterjet apparatus as claimed in claim 1 further comprising a trigger for activating the ultrasonic generator to transform a continuous waterjet into a pulsed waterjet.

8. An ultrasonic waterjet apparatus as claimed in claim 7 wherein the trigger is located on the gun.

9. An ultrasonic waterjet apparatus as claimed in claim 8 wherein the gun is hand-held.

10. An ultrasonic waterjet apparatus as claimed in claim 1 wherein the generator module is mounted on wheels to be mobile.

11. An ultrasonic waterjet apparatus as claimed in claim 1 wherein the generator module further comprises a water dump valve between the high-pressure water inlet and the high-pressure water outlet and an actuator for opening and closing the water dump valve in response to a signal transmitted from a dump valve trigger located on the gun.

12. An ultrasonic waterjet apparatus as claimed in claim 11 wherein the actuator is a solenoid.

13. An ultrasonic waterjet apparatus as claimed in claim 1 further comprising an ultrasonic signal cable for relaying the electrical pulses from the ultrasonic generator to the transducer.

14. An ultrasonic waterjet apparatus as claimed in claim 1 further comprising a compressed air hose for providing compressed air to cool the transducer.

15. An ultrasonic waterjet apparatus as claimed in claim 14 wherein the ultrasonic signal cable is housed within the compressed air hose.

16. An ultrasonic waterjet apparatus as claimed in claim 14 wherein the generator module further comprises a compressed air inlet and a compressed air outlet, the compressed air outlet being connected to the compressed air hose.

17. An ultrasonic waterjet apparatus as claimed in claim 1 wherein the high-pressure water hose is sheathed in an abrasion-resistant nylon sleeve.

18. An ultrasonic waterjet apparatus as claimed in claim 1 wherein the ultrasonic nozzle has a single exit orifice.

19. An ultrasonic waterjet apparatus as claimed in claim 1 wherein the ultrasonic nozzle has a plurality of exit orifices.

20. An ultrasonic waterjet apparatus as claimed in claim 1 wherein the ultrasonic nozzle further comprises a rotating nozzle head.

21. An ultrasonic waterjet apparatus as claimed in claim 20 wherein the rotating nozzle head uses the water pressure in the nozzle to be self-rotating.

22. An ultrasonic waterjet apparatus as claimed in claim 21 wherein the ultrasonic nozzle further comprises a rotational damper to reduce the angular velocity of the rotating nozzle head.

23. An ultrasonic waterjet apparatus as claimed in claim 22 wherein the ultrasonic nozzle further comprises a pair of outer jets in fluid communication with the waterjet to provide torque to self-rotate the rotating nozzle head.

24. An ultrasonic waterjet apparatus as claimed in claim 23 comprising a single angled exit orifice.

25. An ultrasonic waterjet apparatus as claimed in claim 22 comprising a plurality of angled exit orifices.

26. An ultrasonic waterjet apparatus as claimed in claim 25 wherein the plurality of angled exit orifices generate torque to self-rotate the rotating nozzle head.

27. An ultrasonic waterjet apparatus as claimed in claim 1 wherein the transducer further comprises a microtip which acts as a velocity transformer by pulsing the waterjet.

28. An ultrasonic waterjet apparatus as claimed in claim 27 wherein the microtip is a stepped cylinder.

29. An ultrasonic waterjet apparatus as claimed in claim 28 wherein the microtip is made of a titanium alloy.

30. An ultrasonic waterjet apparatus as claimed in claim 27 wherein the microtip comprises a stub for connecting to the transducer, a stem for contacting and modulating the waterjet, and a flange between the stub and the stem, the flange defining a nodal

plane at which the amplitude of standing waves set up at the microtip is zero.

31. An ultrasonic waterjet apparatus as claimed in claim 30 wherein the microtip further comprises an O-ring seal at the nodal plane for isolating the transducer from the waterjet.

32. An ultrasonic waterjet apparatus as claimed in claim 31 wherein the O-ring have a hardness rating of at least 85 durometer.

33. An ultrasonic nozzle for use in an ultrasonic waterjet apparatus, the ultrasonic nozzle comprising a transducer for converting high-frequency electrical pulses into mechanical vibrations that pulsate a waterjet flowing through the nozzle, creating a waterjet of pulsed slugs of water, each slug of water capable of imparting a waterhammer pressure on a target surface, the transducer comprising a microtip with a seal for isolating the transducer from the waterjet, the seal being located at a nodal plane where the amplitude of standing waves set up along the microtip is zero.

34. An ultrasonic nozzle as claimed in claim 33 wherein the microtip is a stepped cylinder.

35. An ultrasonic nozzle as claimed in claim 34 wherein the microtip is made of a titanium alloy.

36. An ultrasonic nozzle for use in an ultrasonic waterjet apparatus, the ultrasonic nozzle comprising a transducer for converting high-frequency electrical pulses into mechanical vibrations that pulsate a waterjet flowing through the nozzle, creating a waterjet of pulsed slugs of water, each slug of water capable of imparting a waterhammer pressure on a target surface, the nozzle comprising a rotating nozzle head.

37. An ultrasonic nozzle as claimed in claim 36 wherein the rotating nozzle head is self-rotating by the torque generated by deflecting the waterjet.

38. An ultrasonic nozzle as claimed in claim 37 wherein the rotating nozzle head has two outer jets.

39. An ultrasonic nozzle as claimed in claim 37 wherein the rotating nozzle head further comprises a damper to limit the angular velocity of the rotating nozzle head.

40. A method of cutting with an ultrasonically pulsed waterjet, the method comprising the steps of:

a) forcing a high-pressure continuous-flow waterjet through a nozzle;

b) generating high-frequency electrical pulses;

c) transmitting the high-frequency electrical pulses to a transducer;

d) transducing the high-frequency electrical pulses into mechanical vibrations;

e) pulsating the high-pressure continuous flow waterjet to transform it into a pulsated waterjet of discrete water slugs, each water slug capable of imparting a waterhammer pressure on a target surface; and

f) directing the pulsated waterjet onto a material to be cut.

41. A method of cleaning with an ultrasonically pulsed waterjet, the method comprising the steps of:

a) forcing a high-pressure continuous-flow waterjet through a nozzle;

b) generating high-frequency electrical pulses;

c) transmitting the high-frequency electrical pulses to a transducer;

d) transducing the high-frequency electrical pulses into mechanical vibrations;

e) pulsating the high-pressure continuous flow waterjet to transform it into a pulsated waterjet of discrete water slugs, each water slug capable of imparting a waterhammer pressure on a target surface; and

f) directing the pulsated waterjet onto a material to be cleaned.

42. A method of cleaning as claimed in claim 41 further comprising the step of self-rotating a rotating

nozzle head so that the pulsated waterjet strikes a larger surface area.

43. A method cleaning as claimed in claim 41 further comprising the step of splitting the pulsated waterjet into a plurality of sub-waterjets so that the sub-waterjets strike a larger surface area.

44. A method of deburring with an ultrasonically pulsed waterjet, the method comprising the steps of:

a) forcing a high-pressure continuous-flow waterjet through a nozzle;

b) generating high-frequency electrical pulses;

c) transmitting the high-frequency electrical pulses to a transducer;

d) transducing the high-frequency electrical pulses into mechanical vibrations;

e) pulsating the high-pressure continuous flow waterjet to transform it into a pulsated waterjet of discrete water slugs, each water slug capable of imparting a waterhammer pressure on a target surface; and

f) directing the pulsated waterjet onto a material to be deburred.

45. A method of removing surface coatings with an ultrasonically pulsed waterjet, the method comprising the steps of:

a) forcing a high-pressure continuous-flow waterjet through a nozzle;

b) generating high-frequency electrical pulses;

c) transmitting the high-frequency electrical pulses to a transducer;

d) transducing the high-frequency electrical pulses into mechanical vibrations;

e) pulsating the high-pressure continuous flow waterjet to transform it into a pulsated waterjet of discrete water slugs, each water slug capable of imparting a waterhammer pressure on a target surface; and

f) directing the pulsated waterjet onto the surface coating to remove the coating from the surface.

46. A method of cleaning as claimed in claim 45 further comprising the step of self-rotating a rotating nozzle head so that the pulsated waterjet strikes a larger surface area.

47. A method cleaning as claimed in claim 45 further comprising the step of splitting the pulsated waterjet into a plurality of sub-waterjets so that the sub-waterjets strike a larger surface area.

48. A method of breaking rock-like materials with an ultrasonically pulsed waterjet, the method comprising the steps of:

a) forcing a high-pressure continuous-flow waterjet through a nozzle;

b) generating high-frequency electrical pulses;

c) transmitting the high-frequency electrical pulses to a transducer;

d) transducing the high-frequency electrical pulses into mechanical vibrations;

e) pulsating the high-pressure continuous flow waterjet to transform it into a pulsated waterjet of discrete water slugs, each water slug capable of imparting a waterhammer pressure on a target surface; and

f) directing the pulsated waterjet onto the rock-like material to be broken.